

High Performance Computing for CAE simulation

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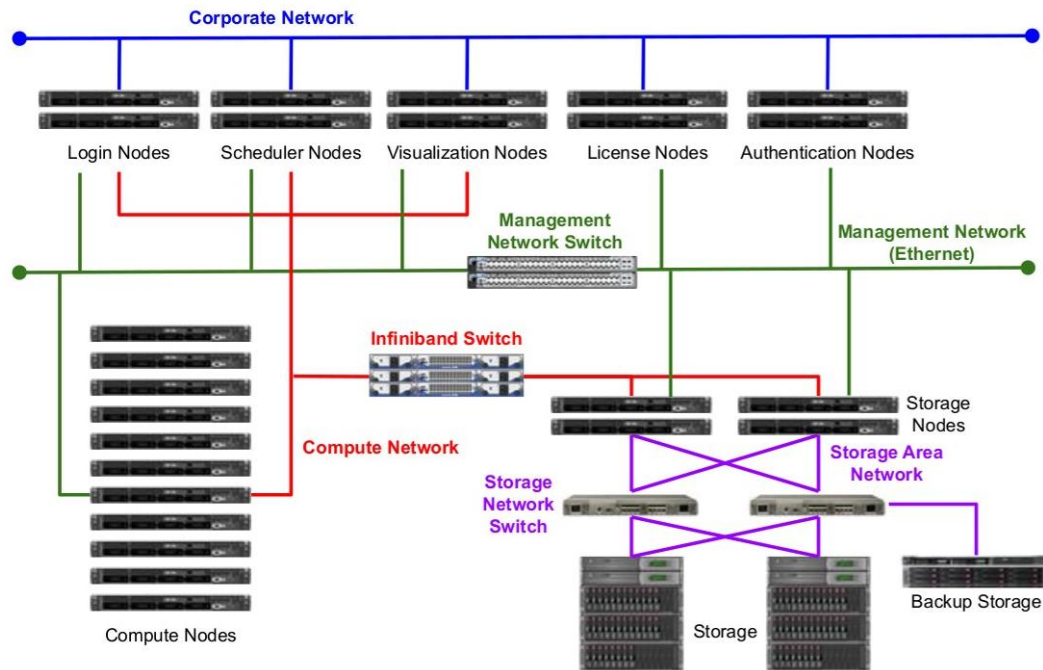
CPO (Chief Product Officer)

NEXTFOAM

Need for high performance computing in CAE simulation

- **Massive computational resources**
 - Parallel processing speeds up calculations significantly by enhanced computational power
- **Handling larger data sets and intricate geometries**
 - Manages more parameters for advanced modeling and increased simulation complexity
- **Simulates finer details for improved accuracy and resolution**
 - Crucial for predicting real-world behaviors in simulations
- **Accelerates multiple iterations within shorter timeframes to reduce time to solution**
 - Enables quicker design decisions and model refinement.
- **Scalability and flexibility for growing computational requirements**
 - Adapts to varying project demands, from small tasks to large simulations.
- **Enabling Advanced Algorithms to support complex solvers and algorithms**
 - Allows for advanced methods like multi-scale modeling and machine learning

On-premise HPC architecture and simulation workflow



- User / Management Server
 - Login nodes : user login & job submission
 - Scheduler nodes : scheduling HPC jobs (LSF / PBS / Slurm)
 - Visualization nodes : pre & post processing with GPGPU
 - License & Authentication nodes : manage licenses and user auth
- Compute nodes with high performance processors and memory
- Management network to manage and monitor the HPC
- Compute network to handle MPI & File I/O communication
- Storage systems
 - Shared storage for scratch data and permanent simulation data

If the job fails, restart from the preparation step

Preparation

- meshing and preparing job scripts
- requires large local infra for large case

Transfer inputs

- login to HPC and upload input files
- text-based and requires high speed network

Job submission

- jobs are queued until resources are available
- longer waiting time on limited resources

Job execution

- when resources are available, jobs are executed
- monitoring is performed text-based

Post processing

- download results to local workstation with long transfer time
- limited visualization nodes

Challenges in HPC: Adapting to Evolving Simulation workflows

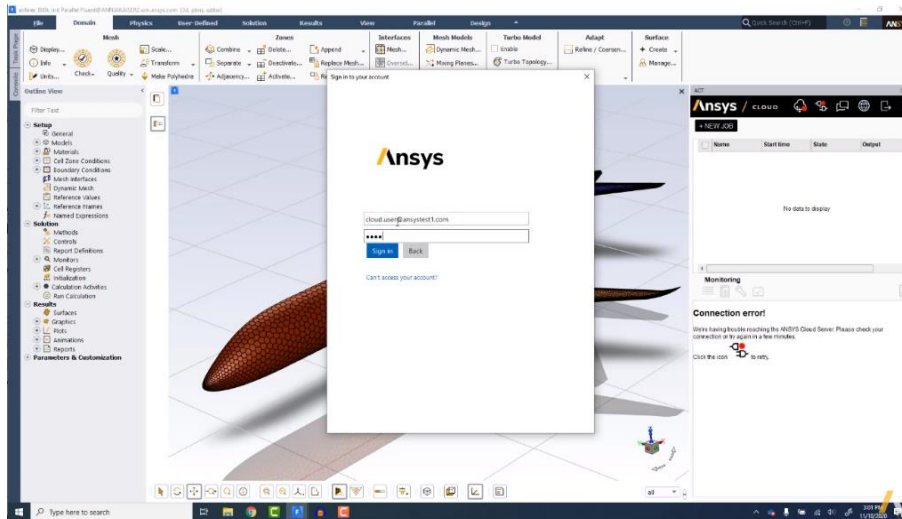
- **GUI-based interactive simulation workflows**

- Enhancement of desktop and workstation performance drives the interactive simulation workflows

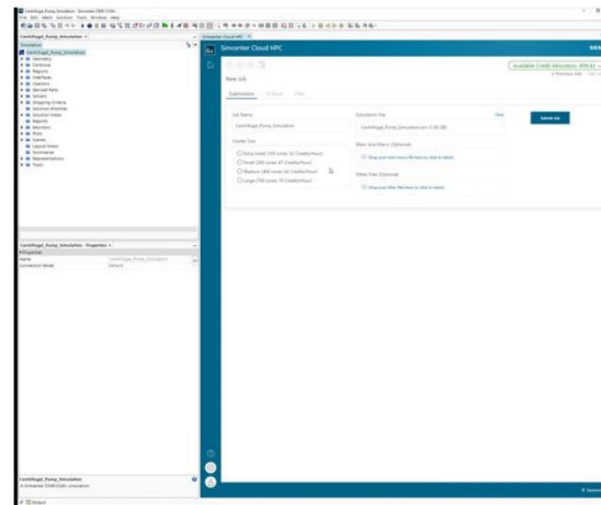
- **Growing demand for seamless integration of IT-based environments, including HPC cloud**

- Ansys Cloud on Azure / Siemens Simcenter Cloud HPC

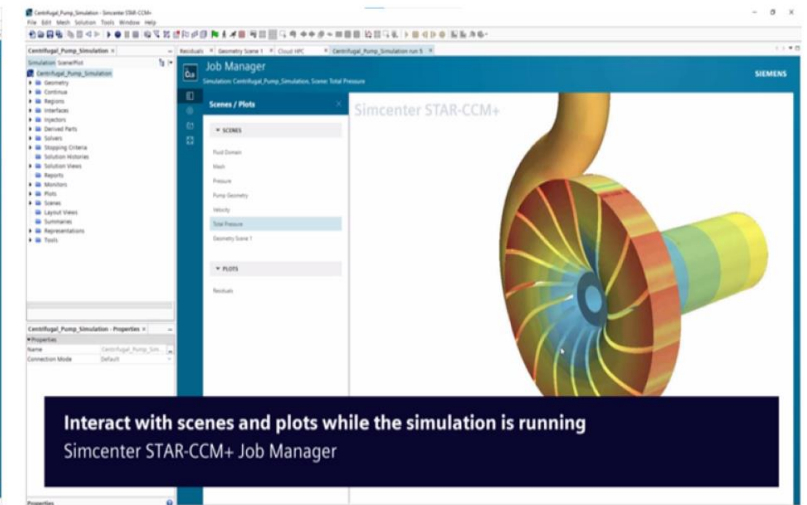
- Run pre- and post-processing on the local desktop and simulations on the cloud HPC environment



Ansys Cloud on Azure



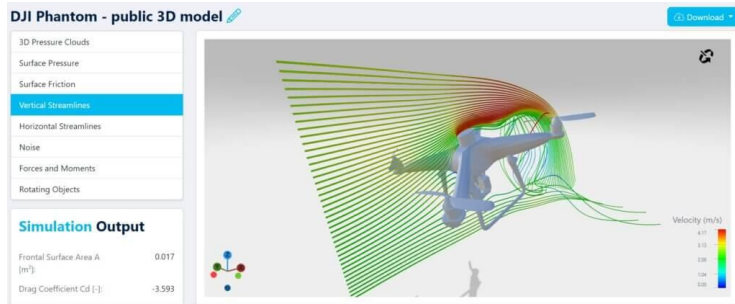
Siemens Simcenter Cloud HPC



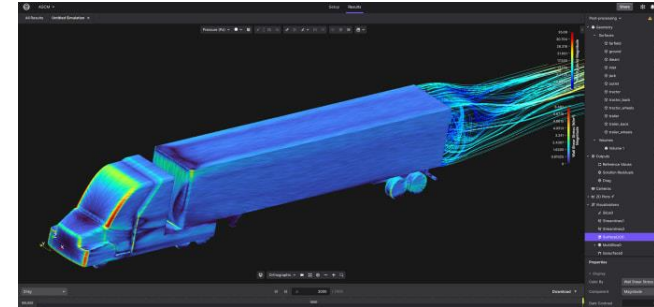
Challenges in HPC: Adapting to Evolving Simulation Workflows

- **Advancement of web-based simulation SaaS services**

- Upload the simulation geometry and conditions to the service, and the entire simulation is performed in the cloud



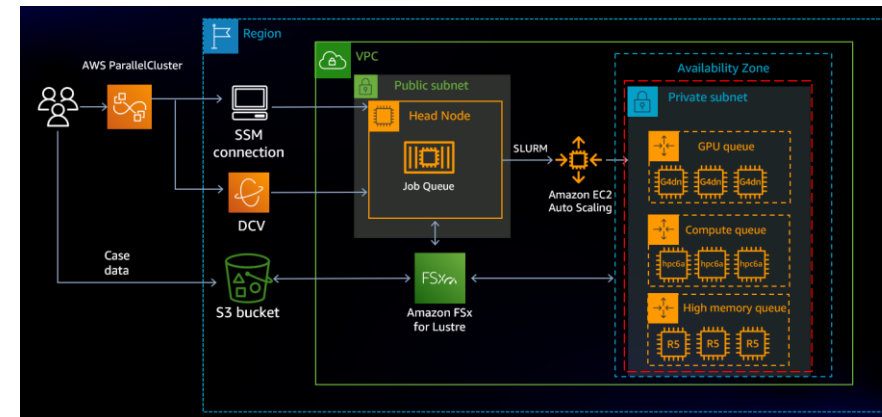
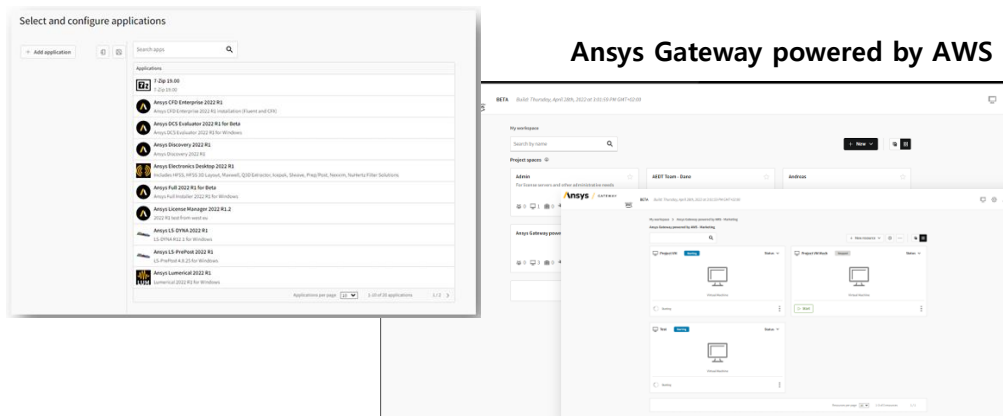
airshaper.com



luminarycloud.com

- **Cloud based HPC services**

- Provide HPC clusters with pre-installed software and perform simulations via a scheduler like traditional HPC in the cloud



AWS ParallelCluster

Next Generation HPC for CAE simulation

• Limitations of traditional and current newly introduced HPC architecture

HPC architectures	Features and limitations
On-premise HPC	<ul style="list-style-type: none">• Long setup time, management overhead and inflexible response to simulation workload and long job queueing• Non-interactive simulation based on batch job scheduler and Frequent data transfer for pre and post processing
Cloud integration of application	<ul style="list-style-type: none">• Seamless integration of interactive applications• Dependency on specific applications and Cloud services, Lack of support for various simulation applications
Web-based simulation SaaS	<ul style="list-style-type: none">• Limited to provided simulation workflows• Challenges in addressing diverse analysis problems
Cloud based HPC service	<ul style="list-style-type: none">• Flexible setup and load response, but non-interactive workflow based on batch processing similar to on-premise HPC• Limited to the workflows and software provided by the service provider

• Future directions of Next Generation HPC

Directions	Features
flexibility and scalability	<ul style="list-style-type: none">• flexible response to varying simulation workloads, reducing job queue times and improving overall efficiency
Interactive workflow	<ul style="list-style-type: none">• Support more interactive simulation environments, allowing for real-time adjustments and analysis
Minimize data transfer	<ul style="list-style-type: none">• Streamline data transfer processes for pre, post-processing to minimize delays and improve workflow efficiency
Application support	<ul style="list-style-type: none">• Expand support for a wider range of simulation applications to accommodate diverse user needs and workflows
Security and Control	<ul style="list-style-type: none">• Maintain high levels of data security and control while leveraging the benefits of cloud-based HPC solutions

NEXTFOAM NextHPC on Azure

- **Flexibility and scalability**

- Microsoft Azure HPC virtual machines can scale to thousands of cores to meet various workload demands, with InfiniBand network support for high-performance, low-latency communication.

- **Interactive workflow**

- Start dedicated HPC clusters using a GUI program without manual configuration as needed
- Connect to the head node using Remote Desktop and perform simulations from pre-processing to post-processing

- **Minimize data transfer**

- Input and result files are stored in each user's blob storage and shared to group blob storage

- **Broader application support**

- Use virtual machine images with pre-installed simulation software available in the Azure marketplace.
- Install your own applications on each HPC cluster as needed.

- **Security and control HPC**

- Data security and controls of HPC are preserved based on Azure RBAC (Role-Based Access Control)

NEXTFOAM NextHPC on Azure

- Launch HPC cluster using GUI and perform interactive simulation

The screenshot displays the 'NextHPC Azure Group Manager' interface. The 'Group Users' section contains a table with the following data:

user type	display name	principal name	created at	account status	resource group
1	group admin	hpc_groupadm...	2024-08-20 23:56:49	Enabled	None

The 'Add New User' button is highlighted with a red box. Other buttons include 'Delete User', 'Enable User', 'Disable User', and 'Open metadata editor'. The 'Member's Clusters' section is currently empty. The 'Cluster Detail' section shows a message: 'Validation successful. Token acquired.' The 'Group Admin Account Detail' section lists various account parameters such as 'admin principal name', 'group display name', and 'default location'.

group admin adds user in their group

NEXTFOAM NextHPC on Azure

• Broader application support with Azure Marketplace images

allowed virtual machine sizes

- Standard_HX176rs
- Standard_HB176-24rs_v4
- Standard_HB176-48rs_v4
- Standard_HB176-96rs_v4
- Standard_HB176-144rs_v4
- Standard_HB176rs_v4
- Standard_E112ias_v5
- Standard_E112iads_v5
- Standard_FX4mds

allowed os images

Publisher: nextfoam, Offer: nextfoam_baram24_ubuntu_x86, SKU: nextfoam_baram24_ubuntu_x86

Microsoft | Azure Marketplace

Browse apps

Get Started

AI + Machine Learning

Analytics

Blockchain

Compute

Containers

Databases

Developer Tools

DevOps

Identity

Integration

Internet of Things

IT & Management Tools

Media

Microsoft Entra ID

Migration

Mixed Reality

Monitoring & Diagnostics

Networking

Security

Storage

Web

Trials: All

Pricing Model: All

Operating System: All

Product Type: All

Publisher: All

Reset filters

All results

HPCBOX: HPC Cluster for OpenFOAM

OpenFOAM v2406 with NVIDIA AmgX for...

CFD Direct From the Cloud

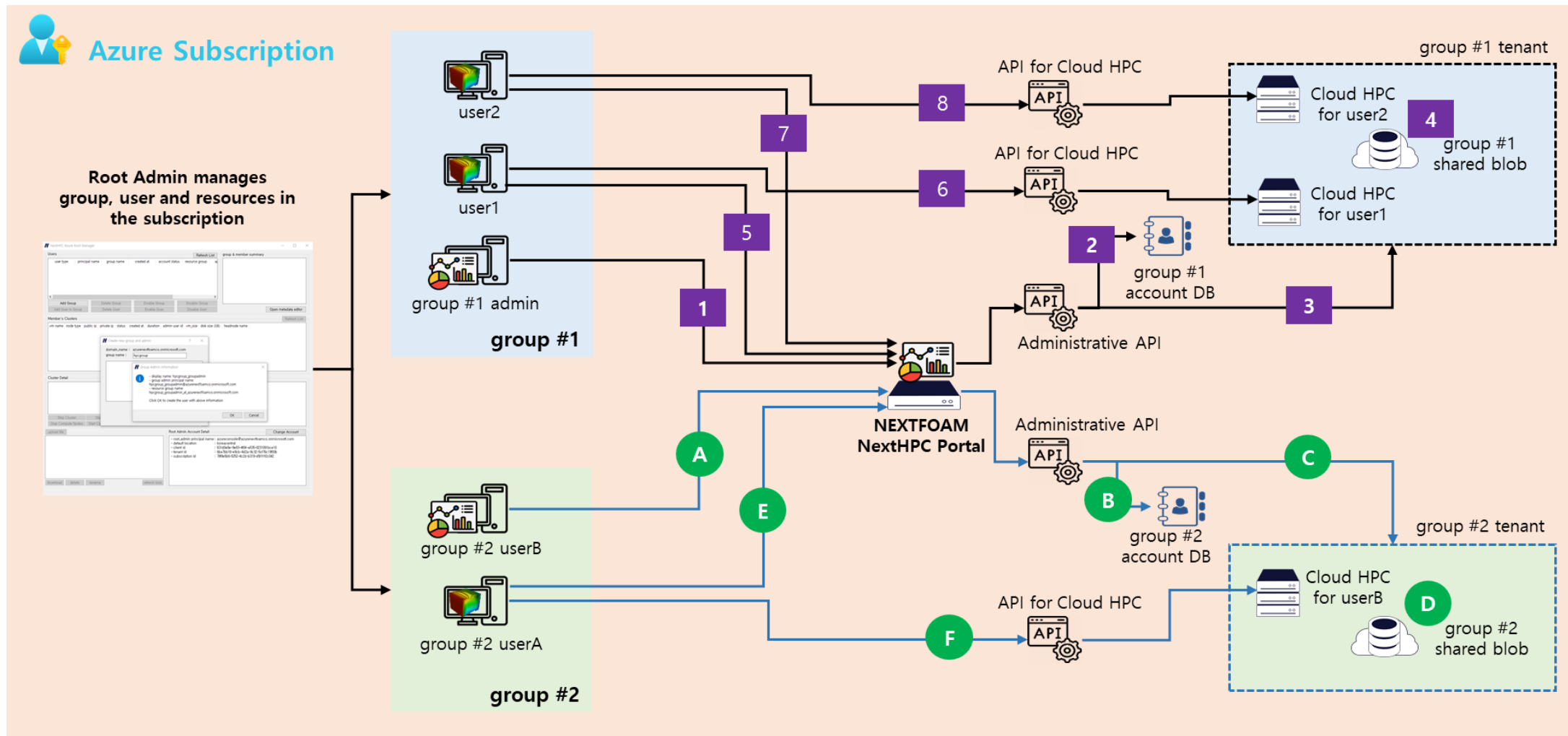
NEXTFOAM BARAM CFD 24.3.3 for Windows 202...

NEXTFOAM BARAM CFD 24.2.0 for ARM64 Ubuntu

NEXTFOAM BARAM CFD 24.3.3 for Ubuntu 22.04...

NEXTFOAM NextHPC on Azure

• Azure RBAC based data security and controls of HPC



Concluding remarks

- **Need for HPC in CAE Simulation**

- Handles complex simulations with large data sets efficiently
- Speeds up computations, enabling faster design decisions
- Enhances accuracy through detailed and precise simulations
- Adapts to varying project demands, from small to extensive analyses
- Scales to meet growing computational needs

- **Future Direction of Next Generation HPC**

- Offers flexible responses to varying simulation workloads
- Supports interactive workflows for real-time adjustments
- Minimizes data transfer delays for improved efficiency
- Expands support for a wider range of simulation applications
- Maintains high levels of security and control in cloud environments

